Fatty acid content of Creole-Nubia goat milk with different seasonal diets in an intensive feeding system in an arid region

Contenido de ácidos grasos en leche de cabra criolla-Nubia con diferentes dietas estacionales en un sistema de alimentación intensiva en una región árida

Teor de ácidos graxos do leite de cabra Crioula-Núbia com diferentes dietas sazonais em um sistema de alimentação intensiva em uma região árida

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Abstract

The objective is to determine the seasonal-diet effect (dry, rainy) on goats' milk fatty acid profile reared on a farm with an intensive production system located in an arid zone of Mexico. In the rainy season, a group of 10 goats, Creole × Anglo-Nubian, consumed a diet composed exclusively of alfalfa hay (*Medicago sativa* L.). Meanwhile, in the dry season, a similar goat group ate a mixture of corn (*Zea mays* L.) and sorghum grains (Sorghum bicolor (L.) Moench, 1794) and buffel grass hay (*Cenchrus ciliaris* L.) in a 1:1:1 ratio. The goats were between 90 and 180 days of lactation. The saturated, monounsaturated, polyunsaturated, and branched-chain fatty acids in milk were measured. The rainy-season milk showed a higher content of fatty acids; however, the contents of most types of fatty acids were not significant between seasons, except for the polyunsaturated (18:2 n-6, α-linoleic acid) and highly unsaturated fatty acids (arachidonic, eicosapentaenoic, and docosahexaenoic acid).

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Resumen

El objetivo es determinar el efecto de la dieta estacional (seca y lluviosa) en la composición de ácidos grasos en la leche de cabras estabuladas en una zona árida de México. Durante la época de lluvias, un grupo de 10 cabras, criolla × Anglo-Nubia, consumieron una dieta compuesta exclusivamente de heno de alfalfa (*Medicago sativa* L.). En la época seca, un grupo similar de cabras consumió una mezcla de granos de maíz (*Zea mays* L.), granos de sorgo (*Sorghum bicolor* (L.) (Moench, 1794) y heno de pasto buffel (*Cenchrus ciliaris* L.), en una proporción 1:1:1. Las cabras estaban entre 90 y 180 días de lactación. La composición de ácidos grasos saturados, monoinsaturados, poliinsaturados y de cadena ramificada se determinó en leche. Los resultados mostraron un contenido de ácidos grasos mayor durante la época de lluvias; sin embargo, la mayoría de las diferencias en los tipos de ácidos grasos fueron no significativas, excepto para los ácidos grasos poliinsaturados (18:2 n-6, α-ácido linoleico) y los ácidos grasos altamente insaturados (ácido araquidónico, eicosapentaenoico y docosahexaenoico).

Palabras clave: estaciones seca y lluviosa, caprinos lecheros, contenido de ácidos grasos, confinamiento.

Resumo

O objetivo é determinar a variação sazonal (seca e chuvosa) da qualidade da composição de ácidos graxos em um sistema de produção intensivo em uma região árida de México; especificamente em termos da composição de ácidos graxos saturados, monoinsaturados (MUFA), poliinsaturados (PUFA) e de cadeia ramificada. Durante a estação chuvosa, a dieta aplicada aos caprinos foi alfafa (*Medicago sativa* L.), e na estação seca, uma mistura de milho (*Zea mays* L.), grãos de sorgo (*Sorghum bicolor* (L.) Moench, 1794) e feno de capim-buffel (*Cenchrus ciliaris* L.) foi fornecido na proporção de 1:1:1. Dois grupos de 10 crioulos × anglo-nubia foram amostrados durante o estudo; as amostras de leite foram coletadas no final da estação chuvosa (dezembro) e durante a estação seca (junho) ordenha manual uma vez ao dia entre 7:00 e 9:00 h, 25 mL de leite de ambos os horários foram coletados de cada amostra coletada quando estava entre 90 e 180 dias de lactação. Os resultados mostraram um maior teor de ácidos graxos durante a estação chuvosa, mas não foram encontradas alterações significativas no conteúdo para a maioria dos ácidos graxos totais, exceto para os ácidos graxos poliinsaturados (18:2 n-6, α-ácido linoleico) e ácidos graxos altamente insaturados.

Palavras-chave: seca e chuvosa, cabras leiteiras, teor de ácidos graxos, confinamento.

Introduction

Goats are well-adapted animals to arid regions, and their milk is a rich source of bioavailable fat (Evershed *et al*., 2008). The goat-milk fat micelles have a small diameter and are mainly composed of short- and medium-chain fatty acids (Chen *et al*., 2016). These fatty acids have great digestibility and absorption and benefit for human health (Milewski *et al*., 2018). The fatty acids in goat milk are readily digested and absorbed by humans and are not only nutritious but aid in the overall health of the individual. Some of its beneficial properties are anti-obesity, anti-carcinogenic, and anti-diabetic (Belury, 2002).

The animal production system and the diets used affect goat milk quality, such as grazing (extensive system) and controlled feed in confinements (intensive system) (Renna *et al*., 2012). Considering that goat farming is developed in arid and semi-arid regions of Mexico, a better understanding of goat milk quality in extensive production systems is imperative, because of is the main production system used in these areas. In this farming system goats graze freely on native vegetation, which could vary due to season and rainfall amount (Manzano *et al*., 2000). However, the use of intensive production systems on farms has increased in Mexico. The objective is to determine the saturated, monounsaturated (MUFA), polyunsaturated (PUFA), and branched-chain fatty acid composition of goat milk in an intensive production system in two seasonal diets (dry and rainy) in an arid zone of Mexico.

Material and methods

Study area

This study was carried out on a private goat farm located at 25º11’55’’ N and 111º42’07’’ W, in Los Algarrobos, agricultural field in Ciudad Insurgentes, B.C.S., Mexico. In this arid zone, the dry season is between January and June, and the rainy season is between July and December. The mean temperatures are 18.7 ºC during the rainy and 22.1 ºC during the dry season (INEGI, 2006).

Animals

Twenty lactating Creole × Anglo-Nubian goats (n=20) of 56 ± 2.0 kg live weight and 3.0 ± 0.5 (1-5 scale) body conditions were used in the study. The does were not pregnant and in good health. The does were in their 2nd or 3rd lactation, and the average milk production in the samplings was 1.4 ± 0.2 L per day.

One group of 10 does per season were sampled. Ten goats were housed in a 40-m^2 pen (5 m × 8 m), which gave an area of 2 m^2 per animal, with drinkers and feeders. Goats were kept in confinement and fed *ad libitum.* The milk samples were collected twice each season: March and June in the dry and September and December in the rainy season (20 milk samples per season). The milk samples were collected by manual milking once daily between 7:00 and 9:00 h. The does were between 90 and 180 days of lactation. According to Kelsey *et al*. (2003) days on milk do not affect the fatty acids content. Twenty-five milliliters of milk were collected per goat in a sterile Falcon tube that was sealed, tagged, and placed on ice to carry to the laboratory. The milk samples were stored at -80 °C until their chemical analysis. The milk samples were analyzed by triplicate.

Seasonal diets ingredients

The diets were offered *ad libitum* to both groups throughout lactation; however, a baseline of 3 % body weight daily consumption on a dry basis per animal was considered. The rainy-season diet consisted of exclusively lucerne hay (*Medicago sativa* L.) and the dry-season diet was a mixed ration consisting of 33 % sorghum grain (*Sorghum bicolor* (L.) Moench, 1794), 33 % corn grain (*Zea mays* L.), and 33 % buffel grass hay (*Cenchrus ciliaris* L.). Feed sampling was done at the same time as milk sampling.

Seasonal diets chemical composition

The diets samples were dried at 100 ºC for dry matter (DM) determination and dried at 55 ºC for chemical analysis until constant weight in an oven (HTP-80, Ariston Thermo®, MA, USA). Samples for chemical analysis were ground to ≤ 1 mm size. Ash (A) was determined by combustion at 600 °C for 5 hours using a muffled furnace (Thermoline 6000, Dubuque IA, USA). The Micro-Kjeldahl method was used to measure the total nitrogen (TN); crude protein

(CP)=TN×6.25. Crude fiber (CF), gross energy (GE), and ether extract (EE) were analyzed by standard methods (AOAC, 2005). Ether extract (lipids) were analyzed by the Soxtec Avanti method (AOAC, 2005). Nitrogen-free extract (NFE) was calculated arithmetically: 100 % - (% moisture + % EE + % CP + % CF + % A). The diet samples were analyzed in triplicate. Data of the two samples per season were averaged.

Composition of milk fatty acids

Standard methods were used to extract milk lipids (Bligh and Dyer, 1959). Total lipids were quantified by the accepted standard methodology (Marsh and Weinstein, 1966). The concentration of the fatty acids was measured in a chromatograph-gas spectrophotometer (Varian CP3800-1200, SpectraLab®, Canada) at 375 nm having a 30 m length OmegaWax® 250 (Sigma-Aldrich Co., Missouri, USA) capillary column made of fused polyethylene glycol silica, at a flow rate of 1.2 $mL.min^{-1}$, with 0.25 µm/0.25 mm (inner diameter/film thickness). Wsearch32 Version 1.6 was used to identify the fatty acids and concentration by interpolating the area of peaks and by using as a reference five known concentrations of 37 standard esterified methyl fatty acids (FAME mix, 37 components, Supelco, TraceCERT®, Sigma-Aldrich Co., Missouri, USA) at five concentration values (5, 10, 20, 40 and 80 $\mu g.mL^{-1}$).

Statistical analyses

Statistica® v. 13.5 (TIBCO® Software Inc., 2018) was used to analyze the data by univariate analysis of variance. Homogeneity of variance was determined using Bartlett's Box-test. The Tukey's HSD was used to assess statistical differences between means and two *p*-values were used for testing significance, $p<0.05$ and $p<0.01$. The following statistical model was used:

$$y_{ij} = \mu + s_i + \varepsilon_{ij}$$

in which is the quantitative response variable, µ is the overall mean, = the seasonal diets; random experimental error.

Results and discussion

Seasonal diets chemical composition

The chemical composition of dry and rainy seasonal diets is shown in table 1. The rainy-seasonal diet had greater content of GE, CP, and A ($p<0.05$); meanwhile, the dry-seasonal diet had greater content of DM, EE, CF and NFE ($p<0.05$).

Composition of milk fatty acids

There were no significant differences between seasonal diets for saturated, branched-chain, Omega-3, and Omega-6 fatty acids in the milk. The milk Omega-3/Omega-6 fatty acid ratio was not different between seasonal diets. The rainy-seasonal diet had a higher amount of polyunsaturated fatty acids than the dry-seasonal diet ($p<0.05$); it was 5-6 % greater in the rainy seasonal diet than in the dry seasonal diet (table 2).

The higher total content of polyunsaturated fatty acids in the rainy seasonal diet (table 2) agrees with Moate *et al*. (2007). Polyunsaturated fatty acids are widely reported in milk, and their presence and differences may be due to seasonal variation of the anaerobic fungi population in the rumen (Koppova *et al*., 2008). Milewski *et al*. (2018) reported that the fat from winter milk showed higher content of long-chained SFA and MUFA than the summer milk. The goat-milk fatty acid content is affected by variables such as dietary fat supplementation (Ayeb *et al*., 2015) and season (Czarniawska-Zajac *et al*., 2006).

Table 1. Chemical analysis of the seasonal diets of goats in an intensive system in an arid zone of Mexico.

	Seasonal diets		
	Rainy (Diet 1)	Dry (Diet 2)	Significance
Dry matter (%)	92.37±0.05 b	94.05±0.18 a	NS
Crude protein (%)	17.68±0.35 a	9.31±0.07 b	**
Crude fiber (%)	20.69±0.20 b	22.52±0.22 a	**
Ash (%)	11.17±0.04 a	8.21±0.05 b	**
Nitrogen-free extract (%)	49.72±0.52 b	58.38±0.23 a	**
Gross energy ($Mcal.kg^{-1}$)	4453.44±29.82 a	4244.39±17.19 b	**
Ether extract (%)	0.72±0.02b	1.56±0.09 a	**
Fatty acids (%)	11.40±1.23 b	28.04±2.14 a	**
C12:0	0.00±0.0 a	0.00±0.0 a	NS
C14:0	0.14±0.01 a	0.13±0.03 a	NS
C16:0	2.67±0.98 b	4.13±0.085 a	*
C18:0	0.68±0.03 b	1.27±0.12 a	*
C18:1	1.13±0.96 b	4.29±1.04 a	*
C18:2	3.26±0.87 b	13.25±1.23 a	**
C18:3	0.00±0.0 b	3.64±0.05 a	**

Dry-season diet: a mixture of sorgo and corn grains, and buffel grass hay (a rate of 1:1:1, as a fed); rainy-season diet: lucerne hay. NS= Not significant (p>0.05); *= p<0.05; **= p<0.01. Rows with different letters differ significantly (Tukey HSD p=0.05). The values represent the mean ± the standard deviation.

Table 2. Major classes of fatty acids ($\mu g.mg^{-1}$) concentration of goat milk-fed in an intensive system with different seasonal diets in an arid zone of Mexico.

Fatty acids (FA)	Seasonal diets		
	Rainy (Diet 1)	Dry (Diet 2)	Significance
Saturated	975.2±156.19 a	895.3±150.30 a	NS
Monounsaturated	242.3±33.20 a	159.9±36.96 a	NS
Polyunsaturated	82.7±9.68 a	66.1±18.43 b	*
Branched-chain	49.6±4.53 a	40.2±7.96 a	NS
Omega-3	26.3±1.46 a	21.4±1.21 a	NS
Omega-6	57.9±3.78 a	48.8±2.89 a	NS
Omega-3/ Omega-6 ratio	0.45±0.04 a	0.44±0.07 a	NS

NS= Not significant (p>0.05); *= p<0.05. Rows with different letters differ significantly (Tukey HSD p=0.05). The values represent the mean ± the standard deviation.

Two FA of very low concentration, eicosanoic (C20:0) and heneicosanoic acids (C21:0), were found in both dry and rainy seasons; being less abundant in the dry season ($p<0.01$) (table 3). The oleic acid (C18:1 n-9) was far from the copious monounsaturated FA in both sampling seasons, coinciding with Chilliard *et al*. (2005). Yurchenko *et al*. (2018) indicate that the FA profile C18:1 n-9 is high in the Swedish Landrace breed milk. The origin of the large proportions of oleic acid could be due to elevated production of delta-9-desaturase that readily catalyzes 18-carbon FA in the mammary gland

Table 3. Saturated and monounsaturated fatty acids concentration (µg.mg^{-1}) in the milk from goats fed in an intensive production system with different seasonal diets in an arid zone of Mexico.

Saturated FA	Seasonal diets		
	Rainy (Diet 1)	Dry (Diet 2)	Significance
C12:0	109.64±34.95 a	106.61±60.61 a	NS
C13:0	2.31±0.52 a	2.10±1.14 a	NS
C14:0	259.04±69.99 a	243.84±98.40 a	NS
C15:0	24.08±6.27 a	21.75±8.25 a	NS
C16:0	420.40±318.33a	358.40±316.99 a	NS
C17:0	16.42±4.01 a	14.61±6.28 a	NS
C18:0	147.69±56.00 a	118.90±101.31 a	NS
C19:0	3.01±0.87 a	2.19±0.73 a	NS
C20:0	5.65±1.34 a	3.52±1.98 b	**
C21:0	1.99±0.47 a	1.28±0.44 b	**
C22:0	2.73±0.61 a	2.36±0.80 a	NS
C23:0	2.67±0.59 a	2.57±0.98 a	NS
Monounsaturated FA			
C14:1 n-5	8.63±1.31 a	3.15±1.20 a	NS
C14:1 n-7	0.87±0.33 a	0.55±0.25 a	NS
C15:1 n-7	3.15±0.48 a	2.06±1.17 b	**
C16:1 n-1	0.92±0.36 a	0.81±0.38 a	NS
C16:1 n-3	1.13±0.20 a	0.73±0.45 b	**
C16:1 n-5	2.18±0.70 a	1.75±0.47 a	NS
C16:1 n-7	15.22±4.30 a	15.10±3.80 a	NS
C16:1 n-9	5.62±1.11 a	5.25±2.54 a	NS
C17:1 n-3	6.57±1.87 a	4.93±3.05 a	NS
C17:1 n-5	0.38±0.23 a	0.19±0.92 a	NS
C18:1 n-3	5.24±0.18 a	3.06±0.31 b	**
C18:1 n-5	3.95±1.03 a	1.51±0.99 b	**
C18:1 n-6	11.26±3.12 a	4.60±3.18 b	**
C18:1 n-7	3.27±0.14 a	1.39±0.30 b	**
C18:1 n-9	153.97±1.01a	95.35±1.11 b	**
C18:1 *trans*	15.46±3.29 a	9.03±4.74 a	NS
C19:1	1.93±0.74 a	1.63±0.82 a	NS
C20:1 n-11	3.86±0.26 a	1.54±0.63 b	**
C20:1 n-3	0.38±0.02 a	0.16±0.08 a	NS
C20:1 n-9	1.01±0.05 a	0.36±0.03 b	**
C22:1 n-9	0.00±0.00	0.00±0.00	NS
C24:1 n-9	2.54±0.90 a	1.63±0.44 b	**

NS= Not significant (p>0.05); **= p<0.01. Rows with different letters differ significantly (Tukey HSD p=0.05). The values represent the mean ± the standard deviation.

(Chilliard and Lamberet, 2001). This seasonal variation coincides with a study of Delgadillo-Puga *et al*. (2009) who found differences in FA in cheese in different seasons. Also, the rainy-season milk had higher concentrations of monounsaturated FA than the dry-season milk. These differences could be attributed to the higher availability of 18-carbon FA in rainy-season forages (Lock and Garnsworthy, 2003).

Total monounsaturated FA did not show significant differences among seasons; however, the concentration of some individual monounsaturated FAs was higher in the rainy season than in the dry season (p<0.01; table 3). Many isomers of C16:1 and C20:1 were identified in this study, albeit at very low concentrations had higher concentrations in the rainy seasonal diet. The low concentration of these isomers could be attributed to the low activity of the enzyme delta-9-desaturase for fatty acids of less-18-carbon chains (Christie, 1995). Cabrita *et al*. (2007) argue that the *de novo* synthesis from acetate is the primary source of less-18-carbon fatty acids in the mammary gland. However, Yurchenko *et al*. (2018) reported that fatty acids C12 to C16, C18:1, and half of the long-chain FAs (≥ C18) are sensitive to feeding, and C4:0-C14:0 FAs are originated by *de novo* synthesis in the mammary gland.

Significant differences of linoleic acid were shown between seasons, being higher during the rainy season. The proportions obtained coincide with those reported by Christie (1995). The differences due to seasons could be that the fodder given to the goats is fresher in the rainy season, leading to higher polyunsaturated FA concentrations (Elgersma *et al*., 2006). This assumption seems to be generally correct because fresh food availability in the rainy season is associated with higher concentrations of polyunsaturated FA. In this regard, Lock and Garnsworthy (2003) noted that unsaturated FA concentrations depend largely on the ruminal production of vaccenic acid and is produced through the biohydrogenation of C18:3 y C18:2 by microorganisms in the rumen. If FA C18:3 is in greater amounts in the milk of goats consuming green fodder, then combined endogenous enzymatic conversions in the mammary gland should lead to higher concentrations of vaccenic acid (C18:1trans11/n-7). However, this intensive system showed significant differences in the concentration of linoleic acid, which is contrary to the results reported by Lock and Garnsworthy (2003).

The C18:2 n-6 *cis* (linoleic acid, LA) showed different amounts (p<0.05) between seasonal diets. Also, C19:2, C20:3 n-6, C20:4 n-6 (arachidonic acid, AA), C20:5 n-3 (eicosapentaenoic acid, EPA), C22:5 n-3, and C22:6 n-3 (docosahexaenoic acid, DHA) showed differences between seasons (p<0.01). The amounts of this FA were higher in the milk from the rainy seasonal diet (table 4). In the present study, polyunsaturated FA showed low concentrations in milk.

The proportion of C:12, C:16, CLA and C18:3 was influenced (p<0.05) by the breed-production system. Also, the age of does and lactation stage had a significant impact on the amount of some milk fatty acids (Gharibi *et al*., 2020). For branched FA, C14:0 anteiso had a higher concentration in the rainy-season milk (p<0.01) than in the dry season (table 4). Up to 50 % of the *trans* FA in dairy fat consists of vaccenic acid. Chilliard *et al*. (2000) reported that diets containing oilseeds like soybeans are widely used to feed stabled animals; this is done to manipulate the composition of FA in the animal-origin products. Nudda *et al*. (2005) measured the fatty acid content in the milk and dairy products of sheep fed on native grass, finding that concentrations of C18:3 n-3 decreased 36 % between spring and summer. The quality and quantity of pastures decrease, caused by a lignification process of plant tissues that significantly reduces the degradability of the dry matter of forages

Table 4. Polyunsaturated and branched fatty acids concentration (µg.mg^{-1}) in the milk of goats fed in an intensive production system with different seasonal diets in an arid zone of Mexico.

Polyunsaturated FA	Seasonal diets		Significance
	Rainy (Diet 1)	Dry (Diet 2)	
C18:2 n-5	1.38±0.69 a	1.17±0.41 a	NS
C18:2 n-6 *cis*	45.48±6.38 a	32.77±31.02 b	*
C18:2 n-6 *trans*	1.13±0.53 a	0.88±0.44 a	NS
C18:3 n-3 *cis*	15.51±3.29 a	13.86±5.03 a	NS
C18:3 n-3 *trans*	0.76±0.16 a	0.54±0.14 a	NS
C18:3 n-6	0.57±0.02 a	0.42±0.06 a	NS
C19:2	7.64±2.37 a	3.38±1.29 b	**
C20:3 n-3	0.18±0.02 a	0.14±0.06 a	NS
C20:3 n-6	5.44±0.38 a	2.49±0.76 b	**
C20:4 n-6	5.44±0.43 a	2.49±1.54 b	**
C20:5 n-3	2.21±0.58 a	1.60±1.16 b	**
C22:5 n-3	4.12±0.31 a	2.62±1.02 b	**
C22:6 n-3	1.84±0.98a	0.98±0.03 b	**
Branched FA			
C12:0 iso	2.93±1.20 a	2.24±1.17 a	NS
C13:0 iso	1.94±0.67 a	1.66±0.76 a	NS
C14:0 iso	4.28±3.13 a	4.27±2.44 a	NS
C14:0 *anteiso*	9.94±1.39 a	5.84±2.47 b	**
C15:0 iso	12.04±5.79 a	10.47±3.65 a	NS
C15:0 *anteiso*	0.70±0.30 a	0.42±0.04 a	NS
C16:0 iso	7.07±2.25 a	6.91±3.31 a	NS
C16:0 *anteiso*	9.19±1.77 a	7.32±2.56 a	NS
C17:0 iso	1.33±0.20 a	0.98±0.14 a	NS
C17:0 *anteiso*	0.28±0.01 a	0.16±0.05 a	NS
C18:0 iso	0.77±0.23 a	0.75±0.30 a	NS

NS=Not significant (p>0.05); *=p<0.05, **=p<0.01. Rows with different letters differ significantly (Tukey HSD p=0.05). The values represent the mean ± the standard deviation.

(Nudda *et al*., 2005). Delgadillo-Puga *et al*. (2009) compared animal production systems, grazing against housing, and found that the higher polyunsaturated FA was C18:2 in both treatments. Comparable results were observed in this study. Wolff *et al*. (1995) described that eicosapentaenoic, docosahexaenoic, and other fatty acids of >20 carbons are synthesized in minute quantities. Talpur *et al*. (2008) found that the milk fatty acid composition varies significantly throughout the year in goats on a traditional feeding regimen. This is supported by Bernacka's (2005) results, which indicate extensive differences in the milk composition of goats with different diets in summer and winter. The presence of FA of 20-to-22-carbon chains can be an outcome of the addition of fish oils in the diet because they contribute to lipids content and their inhibitory effect on the saturation of vaccenic acid, favoring *de novo* synthesis (Shingfield *et al*., 2003). Marine-derived ingredients, such as fish meal and oil, are common in feeds or concentrates supplied to animals. Therefore, differences showed in a number of these polyunsaturated FA present during the two seasonal diets, maybe due exclusively to the quantity of food consumed, balanced, or concentrated, since it has been reported that these polyunsaturated FA are lacking in the fat of animals that have not received supplements (Chilliard and Lamberet, 2001).

Feeding forages such as canola silage in fully mixed rations to Alpine goats may modify some polyunsaturated and highly unsaturated fatty acids in milk (Mejía-Uribe *et al*., 2022). The importance of this type of compound is that they are used to develop organoleptic characteristics that are unique to goat milk and its by-products, such as taste and smell (Chilliard and Lamberet, 2001). Eleven branched FAs with 12-18 carbon chains, 4 *anteiso,* and 7 *iso* isomers were detected. It is well known that branched FAs with <11 carbons are mainly found in goat cheese since it is virtually non-existent in bovine milk. Furthermore, this work agrees with Vlaeminck *et al*. (2006), the outstanding branched FAs are those of a 15-carbon chain. These authors also reported that cellulolytic bacteria (e.g., *Ruminococcus flavefaciens*) could cause variations in the branched FA concentrations, and amylolytic bacteria (e.g., *Prevotella ruminicola*) could cause variations of anteiso FAs. Although some of these types of FAs can be synthesized de *novo* in the mammary gland (Chilliard and Lamberet, 2001). In general, there was no seasonal diets variation of most FA concentrations, except C14:0 *anteiso*, which may be due to the variation of amylolytic bacteria in the rumen.

Across all types of fatty acids, polyunsaturated FAs were different between seasonal diets, higher in the rainy season. Meanwhile, the other fatty acid types just trended to show high amounts in the rainy season. For instance, the most plentiful FA type was the saturated fatty acids, 68.0 and 72.7 % in the rainy and dry seasons, respectively, although they do not differ significantly. In order of abundance from greatest to least, the most representative saturated fatty acids were palmitic (C16:0), myristic (C14:0), stearic (C18:0), and lauric (C12:0). They tended to be more abundant in the rainy season. The monounsaturated fatty acids (15-20 % of FA) had minimum concentrations but were the most numerous in isomers. The oleic acid was the most abundant monounsaturated FA, with about 12 % of total FA, and many monounsaturated FA showed significant seasonal differences. The linoleic acid (C18:2 n-6 *cis*) and alpha-linolenic acid (C18:3 n-3 *cis*) were the primary polyunsaturated FA (concentration of 5-6 %), with average concentrations of 3 % and 1.2 %, respectively. Significant seasonal diets differences were found in C18:2 n-6 *cis* polyunsaturated fatty acid and many lower concentration isomers, C19:2, C20:3n-6, C20:4n-6, C20:5n-3, C22:5 n-3, and C22:6n-3, all of them were more abundant in the rainy season. Branched FA concentrations were highly variable; C15:0 *iso*, C14:0 *anteiso,* and C16:0 *anteiso* were the most abundant constituents in the rainy season, but only C14:0 *anteiso* was significantly different. Milewski *et al*. (2018) reported that summer milk had a higher proportion of PUFA n-6 and PUFA n-3 in the fat.

In the quantity of FA, no significant seasonal effects were found in goat milk, except polyunsaturated FA. However, in terms of quality, significant seasonal differences were found in many of the individual constituents of some FA, particularly in monounsaturated and polyunsaturated. The quality of goat milk varies seasonally (dry and rainy), although not the quantity of most FA. The concentration of all FA was greater in the milk collected in the rainy than in the dry season; however, the difference was not significant in some cases. The influence of seasonal diets on the quality of goat milk is associated with seasonal differences in the forage quality provided since the forage used was produced locally. This study identified that there are changes per seasonal diets in the quality of goat milk concerning FA in the intensive production system. In conducting the study, a methodological requirement was to use the same diet that is produced locally with local feedstuffs that farmers use to feed goats. The study has practical utility because it determined the seasonal diets change in the lipids of goat milk. One limitation of the study caused by the need to maintain the same diet as that used by the farmers is that it is not possible to quantify the effect or contribution of the two factors diet or metabolic-environmental in the change of the quality of the milk per season, because both changed during the seasons. Under intensive production system, the goat produces milk that is richer in favorable nutritional components that can contribute to improving the characterization of goat dairy products, thus adding value to its market (Lopez *et al*., 2019).

Conclusions

The content of FA is higher in the rainy seasonal diet. The content of polyunsaturated FA and highly unsaturated FA (AA, EPA, and DHA) are different among seasonal diets.

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